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THE AQUATIC FAUNA OF LOCH LOMOND AND THE TROSSACHS: WHAT HAVE WE GOT; WHY IS IT IMPORTANT; HOW DO WE LOOK AFTER ITS FUTURE

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ABSTRACT

Conservation of the natural heritage is supposed to be a top priority of the Loch Lomond and the Trossachs National Park Authority. Yet sustainable management of wildlife within the Park will only be possible if adequate scientific data on the temporal and spatial status of species and habitats are available. It is therefore important to have reliable information on the present status of aquatic wildlife and to have monitoring programmes which will be sufficient to detect significant changes in the future. However, resource implications mean that only limited long-term monitoring will be possible and suitable strategies must be devised now. Possible species for monitoring include flagship, keystone and indicator organisms as well as certain alien species and important habitats.

INTRODUCTION

If we are to manage the wildlife and habitats of Loch Lomond and the Trossachs we must have an idea of what species and habitats are there and if, through time, these are changing – and whether any changes are desirable or undesirable. If the latter is true, we additionally need to know if there is anything that we can do about it, and perhaps reverse undesirable trends? This paper broadly examines what is known about the aquatic fauna of Loch Lomond and the Trossachs and seeks to identify important species which it is realistic to monitor in order that we may be better able to manage the wildlife resources of the area.

Because of the potential commitment of resources for indefinite periods it is important to consider the cost implications of any monitoring programme which is proposed. Thus the debate must review the pros and cons of any potential project and view widely the options for minimising resource requirements whilst still producing the information essential for future management of species and habitats.

THE AQUATIC FAUNA

Invertebrates

The number of aquatic invertebrates established in the Loch Lomond and the Trossachs area is unknown and almost impossible to establish if microscopic species are included. The fact that several of the less common aquatic habitats have never been examined properly (Maitland 1999) adds to the difficulty of completely describing the current biodiversity. For Scotland as a whole, Usher (1997) estimated that there were some 19,200 terrestrial and freshwater invertebrates, excluding microsopic forms (Viruses, Bacteria, Protozoa etc.). Only a small proportion of these invertebrates are freshwater species and Maitland (1977) listed the known list of aquatic macroinvertebrates in the British Isles as including some 3,800 species – probably at least 50% of these occur in Scotland.

In terms of species lists for known waters within Loch Lomond and the Trossachs area, more accurate information is available. For example, Maitland (1966) recorded 73 macroinvertebrate species in the main stem of the River Endrick (272 for the whole river system) and a similar number (70) was recorded by Doughty & Maitland (1994). In their study of streams in two areas west of Aberfoyle, Harriman & Morrison (1982) recorded 43 different taxa. In Loch Lomond itself, a total of 103 species has been recorded - from the littoral (47 species), profundal (45) and pelagic (11) zones by Smith et al. (1981), Slack (1965) and Maitland *et al.* (1981) respectively. In all cases these are minimum numbers, for some groups were not examined in detail as several diverse groups have only been poorly recorded (e.g. Rotifera, Hydracarina, Diptera) and others not studied at all (Nematoda, Microturbellaria, Tardigrada) in this catchment. Of the groups that have been well documented for the Loch Lomond catchment, this area has records of 331 aquatic species (Adams *et al.* 1990)

Vertebrates

The number of vertebrates in the Loch Lomond and the Trossachs area is much better known than that of invertebrates, as fish, amphibians and birds have been much more intensively studied. Only fish are considered here and elsewhere in this paper. The total number of freshwater fish species known to occur in Scotland is 42 (Adams & Maitland 2001) and of these 35 have been recorded from Loch Lomond and the Trossachs area (Maitland 2002). However, of these 35 species, only 22 are considered to be native (Adams & Maitland 2001), the remainder are alien species introduced mostly in the recent past.

IMPORTANT SPECIES

The decision as to which species are 'important' is a subjective one and can depend on the context involved. For example, rare native species are certainly important and worthy of study and conservation, but so too may be quite common species which have an important, even crucial, ecological role within a given habitat. Species of economic significance must also be deemed important.

Natives

Rare invertebrate species found in Loch Lomond and the Trossachs area include the Lomond worm, *Arcteonais lomondi*, the subterranean crustacean *Bathynella natans*, the mollusc *Bithynia leachii*, and three dragonflies: the Downy Emerald *Cordulia aenea*, Beautiful Demoiselle *Calopteryx virgo* and Northern Emerald *Somatochlora arctica*. Common species of note because of their role in the functioning of aquatic ecosystems, are the worm *Eiseniella* *tetraedra*, the crustaceans *Diaptomus gracilis*, *Gammarus pulex* and *Asellus aquaticus*, the mollusc *Lymnaea peregra*, and the water bug *Sigara dorsalis*. No aquatic invertebrates are of direct economic importance, though biting midges (Ceratopogonidae), some of which are aquatic and which are abundant in the area, might be regarded by some as such.

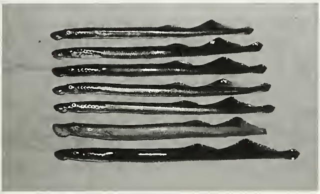

Fig. 1. Loch Lomond river lampreys

Rare freshwater fish within the Loch Lomond and the Trossachs area include the unique form of River Lamprey *Lampetra fluviatilis* (Fig. 1) in Loch Lomond and the River Endrick, the Powan *Coregonus lavaretus* of Lochs Lomond and Eck and the polymorphic Arctic Charr *Salvelinus alpinus* of the Trossachs lochs. Common fish species which are of ecological importance, because of the key role they play in the functioning of aquatic ecosystems in Loch Lomond and the Trossachs area, include Roach *Rutilus rutilus*, Minnow *Phoxinus phoxinus*, Atlantic Salmon *Salmo salar* (particularly the juvenile stage), Brown Trout *Salmo trutta*, Pike *Esox lucius*, Eels *Anguilla anguilla* and Perch *Perca fluviatilis*. Atlantic Salmon and Brown Trout (and to a lesser extent Eels) are of considerable economic importance as they support significant fisheries in the area which make a notable contribution to the local economy (Radford & Gibson 2004). Additionally some fish species found in the area are of importance because of concern about national trends in populations, these include: Eels, regarded as below sustainable exploitation levels internationally (ICES 1998); Atlantic Salmon (in Annex IIa and Va in the Habitats and Species Directive) and the migratory form of Brown Trout (the Sea Trout) which has shown significant declines in some rivers in recent decades (Hay & McKibben 2005).

Aliens

Many alien species are now established in the Loch Lomond and Trossachs area and some have caused significant ecological change. They include invertebrates such as *Potamopyrgus antipodarum* and *Crangonyx pseudogracilis* (Maitland & Adams 2001) and at least 13 alien fish species such as Crucian Carp *Carassius carassius*, Carp *Cyprinus carpio*, Brook Charr *Salvelinus fontinalis*, and Ruffe *Gymnocephalus cernuus* (Adams & Maitland 2001). One important function of monitoring should be to record the first findings of any such species, so that immediate efforts can be made to eliminate them, but also to monitor populations so that their impact on native species and communities can be assessed.

WHAT TO MONITOR?

Flagship species

Flagship species can be defined as a species that can evoke a strong public reaction and through this can promote conservation issues.

Because of their small size and often obscure habits, invertebrates are less easy than vertebrates to promote in this way but there are several important candidates.

Arcteonais lomondi – The first discovery ever of this species was in Loch Lomond, and is reflected in its nomenclature. It has the potential to capture the imagination because of this local historical significance, thus potentially making it a flagship species. Its abyssal habitat is also intriguing. However as with many other invertebrates, this animal does not lend itself to attractive promotional images.

Fig. 2. Freshwater pearl mussel

Freshwater Pearl Mussel *Margaritifera margaritifera* (Fig. 2) – this fascinating but declining large mollusc must surely qualify as a flagship species. Its ability to live for over a century as a calcium demanding bivalve which lives in calcium poor waters, together with its historic role as a producer of freshwater pearls for the Scottish Crown and other regalia, have given it a particular prominence in recent years.

Pisidium conventus – this small bivalve mollusc occurs on the bottom only in the deepest water of Loch Lomond – the 'Tarbet Deep' at 190 m (Hunter & Slack 1958). It has considerable significance here as it considered a good example of an Arctic relict species, found mainly in the profundal areas of deep lochs further north in Scotland and Scandinavia.

Powan (Fig. 3) – This fish - a suitable candidate because its rarity in Scotland and the UK generally - defines in part, some of the special nature of the Loch Lomond and the Trossachs area. A suitable project in Lochs Lomond and Eck could allow the fish community, as a whole, to be covered by a monitoring programme which concentrates on Powan but also samples many other species and could be devised to identify major change in native fish populations and to detect any new arrivals.

Arctic Charr (Fig. 4) – This should be considered as a flagship species, partly because its beauty has an impact amongst those members of the public who do not immediately identify with fish conservation, and partly because the evolutionary story associated with this species has much to reveal to specialists and non-specialists about contemporary evolution.

Fig. 3. Powan

Fig. 4. Arctic charr

Salmon – This is certainly a potential flagship species used successfully as such elsewhere (e.g. in the Thames restoration scheme: Gough 1987). Its complex life cycle, existing public identity as requiring high water quality and economic value make this species ideal for promotion as a potential flagship species. Historically it is closely associated with the City of Glasgow and its Coat of Arms.

Possibly less suitable candidates include:
Eel – The intriguing life cycle of this amazing animal, its ubiquity in freshwater systems and its vulnerability make this a good potential flagship species. However the public persona of the Eel mitigates against it to some extent.

River lamprey – The unusual life cycle of this species in the River Endrick partly defines the unique nature of the Loch Lomond and the Trossachs area and as such is one of the key "stories" that visitors to the area should have the opportunity to learn. Thus this species is a potentially good flagship species for the area, though its feeding habits and lack of photogenicity may work against it.

Keystone species
Keystone species are species which are disproportionately important to the maintenance of community integrity and following whose extinction major ecological changes would ensue.

Invertebrates – Within Loch Lomond, the major water within the National Park (Maitland *et a*l. 2001), and other large lochs, invertebrates need to be considered within each of the three main communities – littoral, profundal and pelagic. Any programme on invertebrates must build upon the standard methodologies and extensive sampling programmes currently operated by the Scottish Environmental Protection Agency (SEPA) to get the best value for effort. For riverine invertebrate communities in particular there are internationally recognised techniques and protocols (e.g. BMWP and RIVPACS) for estimating change which can be incorporated in monitoring.

Littoral – *Gammarus pulex* is a strong contender here, not least because it may be being replaced at the moment by the invasive species *Crangonyx pseudogracilis* (Maitland & Adams 2001). Other important invertebrates include the mayfly *Caenis moesta* – a ubiquitous native of significant importance in aquatic food chains. The littoral zones are highly important to the functioning of lochs but are also very vulnerable to anthropogenic effects. These animals play a key role in their healthy functioning and thus could identify any change.

Profundal – As well as oligochaete worms and sphaeriid bivalves, chironomid midge larvae are important invertebrates in the deep water muds of Loch Lomond. Most characteristic among these are members of the genus *Tanytarsus*, typical of oligotrophic lakes (Slack 1965). Changes in this group of invertebrates would significantly affect the way in which deep water processes in lochs operate.

Pelagic - *Diaptomus gracilis* is the commonest member of the zooplankton in Loch Lomond and has been shown to form at least 40% of the pelagic community (Chapman 1969). Other important zooplankton are *Bosmina coregoni* and *Daphnia hyalina*. These species are principal drivers of food chains in open water in lochs. Their short generation time and the speed at which they respond to environmental change make them potentially sensitive markers of environmental pressures.

Riverine invertebrates – keystone species from rivers and streams within the Loch Lomond and Trossachs area include several species of stoneflies (Plecoptera) and mayflies (Ephemeroptera), two abundant and ubiquitous groups which are known to be sensitive to change in riverine environments.

As with fish communities, invertebrate sampling could concentrate on one (or a few) species within each community but keeping a record (with minimal effort) of other species/taxa to detect change. The value of archive samples for future research projects should also be given serious consideration.

Pike – At the top of the aquatic food chain and with a very wide distribution in Loch Lomond and the Trossachs, pike has the potential to act as a keystone species. Its position in the food chain means that change in aspects of the aquatic ecosystem lower down the trophic cascade is very likely to be manifest in changes in this species. Thus pike can act as an integrator of ecosystem change providing a valuable indicator mechanism - including its tendency to act as a bioaccumulator of anthropogenic toxins such as dieldrin and other pesticides.

Brown Trout – This is the most widespread fish in the area, and often the only species in upland burns and lochs. In these it is the major aquatic predator and with its extinction, as has happened with the acidification of a number of waters, major changes take place in the invertebrate communities (Henriksen & Oscarson 1978, 1981, Lyle & East 1989).

Indicator species

The use of indicator species is well known in ecology and especially important in pollution biology. Once the ecological tolerances of an organism have been defined it is possible to use its presence in a habitat to assume that conditions there lie within these tolerance levels. Hellawell (1986) has noted that ideal environmental indicator species are readily identified, may be sampled easily, have a cosmopolitan distribution, are associated with abundant autecological data, are easily cultured, and have a low genetic and niche variability.

The measure of the impact of global warming is a special issue which is worthy of its own mini programme since there may be general changes resulting, which are driving everything else. It is also feasible in this context to make some predictions and then test them using monitoring records. Several invertebrate species might be good indicators here. The mayfly *Ameletus inopinatus* occurs in the Lomond catchment only at high altitudes (e.g. near the source of the River Endrick). Further south it occurs only at even higher sites, but in the north of Scotland is found down to sea level. Predictably, it will disappear from the Lomond catchment as the climate warms. Another mayfly, *Ephemerella ignita*, at present has only one generation each year in the Loch Lomond area and is only found as larvae during the summer but further south in Britain it is present all the year round, whilst on parts of mainland Europe there may be two generations. Predictably, in the Loch Lomond area, with increasing annual temperatures, the larvae would be present all year round and the number of generations would increase. Monitoring of the distribution of the former and the life cycle of the latter, would provide an index of climate change.

Of course, there are other species which could be considered as useful indicators. Also, such changes may already be happening for no-one has looked at the mayfly species mentioned above for some time.

Fig. 5 Medicinal leech

Restoring biodiversity

Several species are declining in the area and others have become extinct. A notable example of the latter is the Medicinal Leech *Hirudo medicinalis* (Fig 5) which formerly occurred in 'a pool near the Loch of Menteith (Dalyell 1853) – possibly Loch Macanrie (Maitland 1996) – and in 'certain ponds belonging to John Burn Murdoch Esq. of Gartincaber' whose estate lay near Thornhill. In view of the extreme rarity of this species elsewhere in Scotland (only two sites are known) a programme to restore this important species is overdue.

RARE HABITATS

Although a number of the larger rivers and lochs in the area have been studied in the past, very little attention has been paid to less usual, but sometimes common, ecosystems – such as ephemeral ponds and streams, subterranean and interstitial waters, high altitude streams and bog pools, moss cascades and other fascinating habitats (Maitland 1999). Research on these aquatic systems is likely to reveal much of interest, including the possibility of new species in otherwise well known geographic areas. Although many of these habitats are under threat, few have protection and we may well be losing interesting habitats and species without ever knowing anything about them.

BENEFITS AND LIMITATIONS OF MONITORING

Benefits

Small scale, incremental, environmental change is notoriously difficult to demonstrate adequately. Natural variation in the size of populations of plants and animals is frequently large, creating 'noise' that masks underlying (perhaps anthropogenic) trends, that may be of importance. Although highly frustrating for managers of ecosystems, who usually need to make decisions on a much shorter time-scale, it is difficult to identify insidious fine-scale and cumulative incremental ecosystem change without long-term monitoring data. Without these types of data, sound evidence-based ecosystem management decisions to prevent or mitigate against such change is impossible.

We should also attempt to maximise relevant information available from samples if this helps to detect potential stress and serve as a warning for possible future decline of a population. An example of this in relation to fish samples is the analysis of change in fish size, growth rate, condition or parasite load which might be an indirect indicator of more significant undesirable change in the fish community.

Costs

Monitoring anything in perpetuity has a number of resource commitments and should not be undertaken lightly. The costs of field work and any subsequent laboratory or data analyses may be considerable over the long term and a traditional area for those in accounting to terminate when financial resources are limited.

Destructive sampling

Certain types of sampling are destructive and should be avoided if possible – especially if the size of the population is unknown or is believed to be threatened. When there is doubt, the Precautionary Principle should apply and only non-destructive methods employed.

Change of policy

There are many examples of where a change of policy or change of personnel has meant the abandonment of a previous monitoring programme. Any programme which is believed to be of importance should be given periodic guarantees of time-limited continuance, with a review of the project at the end of each period.

Opportunism

In view of the, often high, costs of monitoring and the difficulties of carrying out appropriate sampling any serendipitous opportunities to sample important species or events should be undertaken.

A good example of opportunistic sampling was the coincidence of the discovery of Ruffe in Loch Lomond (Maitland et al. 1983) with the decision to sample fish on the screens of a water supply pumping station at Ross Priory. For relatively little effort it has been possible to monitor several species captured by the intake there, and in particular follow the population explosion of alien Ruffe during their early decades in Loch Lomond (Adams & Maitland 1998).

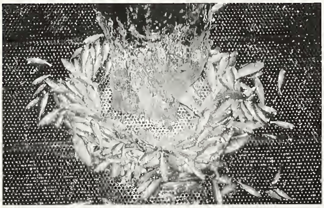

Fig. 6. Fishscreen at Ross Priory

There are many other opportunities to obtain valuable monitoring data with minimal effort, given appropriate circumstances. For example, if Powan are to be monitored regularly at Loch Lomond then the regular recording of scars and wounds on these fish caused by feeding River Lampreys (Maitland 1980) could, for relatively little extra effort, give a valuable indirect method of monitoring adult lampreys in the loch.

One opportunity which has arisen recently is the possibility of monitoring certain groups of adult insects which are collected in the highly efficient midge traps increasingly being installed in the vicinity of hotels and caravan sites in the Loch Lomond and Trossachs area.

MANAGEMENT

A range of organisations have statutory obligations or at least responsibilities to manage species or habitats with the Loch Lomond and Trossachs area. Since it is difficult to manage on a scientific basis without information from monitoring then there is mostly an implied obligation to monitor. Some of the most important of these responsibilities are indicated in Table 1.

CONCLUSIONS

Without reliable scientific data, the Loch Lomond and the Trossachs national Park Authority will not be able to carry out its responsibility to manage the wild life resources of the Loch Lomond and Trossachs area on a sustainable basis. Such data may only be obtained through the implementation of well designed programmes which monitor selected organisms, communities and habitats in the area. However, in order to minimise the implied regular costs of such progammes, each must (a) be carefully designed, and (b) maximise the input from all those concerned, including statutory bodies, NGOs and voluntary bodies such as the Glasgow Natural History Society.

Table 1. Organisations with responsibilities for monitoring and managing aquatic wildlife in the Loch Lomond and Trossachs area.

Organisation	Responsibility	Requirement for aquatic species/habitats
Fishery Trusts	Fish within their areas	Regular assessment of freshwater fish populations
LLTNP	Wildlife within the Park	Co-ordination and archiving of monitoring data
SEPA	Aquatic pollution indicators	e.g. aquatic benthos to detect pollution
SNH	Wildlife within protected areas	e.g. lampreys and salmon in River Endrick SAC

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